REMARKS

Claims 1-14 were previously pending in this application. Claims 1, 5, 7, and 12 have been amended. Claims 1 and 12 have been amended to recite that the senor unit comprises a sensor conduit having a sensor conduit inlet fluidly connected to the fluid inlet and a sensor conduit outlet fluidly connected to the fluid outlet. This amendment is supported throughout the specification, for example, at page 6, lines 16-19 and Fig. 2. Dependent claim 7 has been amended accordingly. New claim 15 has been added and is directed to the orientation of at least one capillary tube substantially along a direction from the fluid inlet to the fluid outlet. As a result claims 1-15 are pending for examination with claims 1, 12, and 14 being independent claims. No new matter has been added.

Claim Objection

Claim 5 was rejected for depending upon itself. Claim 5 has been amended to depend from claim 3. Accordingly, withdrawal of this objection is respectfully requested.

Rejections Under 35 U.S.C. §102

Claims 1, 2, 6-9, 12, and 14 were rejected under 35 U.S.C. §102(b) over U.S. Patent No. 5,837,903 to Weigand (hereinafter Weigand). This rejection is respectfully traversed.

Weigand fails to disclose, teach, or suggest a flow sensor comprising a sensor unit fluidly connected to a fluid inlet and a fluid outlet by a sensor conduit, wherein at least one capillary tube has a length substantially equal to a length of the sensor conduit as recited in independent claim 1. Similarly, Weigand fails to disclose, teach, or suggest, a flow sensor comprising a sensor unit fluidly connected to a fluid inlet and a fluid outlet by a sensor conduit, wherein at least one capillary tube has an entrance effect substantially equal to an entrance effect of the sensor conduit, and the corresponding process, as recited in independent claims 12 and 14, respectively.

Weigand discloses a device for measuring exhaust flow using a laminar flow element. In Weigand, flow meter 10 includes body 12 and a capillary section 18 consisting of an array of capillary tubes. Body 12 includes a first sensing port 22 to detect the pressure adjacent to the inlet of the capillary section 18. (Weigand, column 3, lines 65 through column 4, line 4.) Body 12 also includes a second sensing port 24 to detect the pressure adjacent to the outlet of the capillary section 18. (Weigand, column 4, lines 4-8.) Both sensing ports of Weigand are fluidly connected to secondary readout devices. (Weigand, column 4, lines 8-10).

However, in Weigand, the sensor unit is not fluidly connected to an inlet and an outlet by a sensor conduit. In fact, the inlet of Weigand is fluidly connected to one sensor port and a readout device, while the outlet is fluidly connected to a different sensor port and readout device. Moreover, because each port is used to individually measure the pressures of the bypass inlet and outlet, each sensor port must have its own line to direct flow to the readout devices.

In contrast to Weigand, the sensor conduit of the present invention is connected to both the fluid inlet and the fluid outlet. Specifically, as now recited in each of independent claims 1 and 12, the sensor conduit inlet is fluidly connected to the fluid inlet and the sensor conduit outlet is fluidly connected to the fluid outlet. This is in contrast to Weigand in which a first sensor conduit is fluidly connected to the fluid inlet of the bypass and housing, and another sensor conduit, distinct from the first, is fluidly connected to the fluid outlet of the bypass and housing. Accordingly, as now presented, each of claims 1 and 12 distinguishes over Weigand.

Moreover, each of claims 1 and 12 further patentably distinguishes over Weigand for additional reasons. For example, claim 1 further recites that the at least one capillary tube has a length substantially equal to a length of the sensor conduit. The phrase "substantially equal to" is used to define properties which are identical or nearly identical, including variations which occur during production. (Present application, page 6, lines 23-26.) Because the lengths of the sensor conduit and the at least one capillary tube are substantially equal, the bypass split-ratio remains constant and the range of bypass linearity increases. (Present application, page 7, lines 11-15.) The increased bypass linearity increases the accuracy of the sensor reading over a wide range of flow rates and gas properties, the operable range of the flow sensor is increased at the high flow range of the sensor, and there is greater accuracy when switching between different fluids. (Present application, page 7, lines 15-20.) As further described in Applicant's

specification, further improvements in the bypass split-ratio and bypass linearity may be achieved by designing the inside diameter and the cross-sectional shape of the sensor conduit and the one or more capillary tubes to be substantially the same. (Present application, page 9, lines 21-28.) These further aspects of Applicant's invention are addressed in claims that depend from independent claim 1.

However, Weigand is silent on the relative lengths of capillary tubes of the bypass and the lengths of the sensor connections between the sensor ports and the read out devices. Indeed, although Weigand discloses that in one embodiment, the length of the capillary tubes of the bypass may be "about three inches," nothing is said about the lengths of the coupler and reducer assemblies 26 to which secondary readout devices are attached. In fact, because there is no sensor conduit connected to the inlet and outlet in Weigand, there can be no matching of length and/or entrance effects of a capillary tube compared to a sensor conduit. Accordingly, because Weigand does not disclose, teach, or suggest this aspect of Applicant's invention, claim 1 patentably distinguishes over Weigand.

Independent claim 12 also patentably distinguishes over Weigand, as claim 12 additionally recites that the at least one capillary tube has an entrance effect substantially equal to an entrance effect of the sensor conduit. As described in Applicant's specification at page 9. lines 17-28, by designing the at least one capillary tube of the bypass to have substantially the same entrance effect as that of the sensor, the nonlinear characteristics of the sensor and that of the bypass match each other, to the extent that at a common pressure drop, substantially the same amount of gas will flow through each bypass capillary tube as will flow through the sensor capillary tube. Weigand is silent with respect to the entrance effect of capillary tubes of the bypass and that of the two sensing ports 22, 24. Accordingly, any assertion that Weigand discloses or teaches this aspect of Applicant's invention (and in particular, the Office Action's reference to column 3, line 65 through column 4, line 6 of Weigand) is without any support in Weigand.

Independent claim 14 is directed to a process for measuring fluid flow and also patentably distinguishes over Weigand for reasons similar to claim 12. Claim 14 recites a step of passing a fluid through a sensor unit having a sensor conduit with an entrance effect substantially equal to an entrance effect of at least one bypass tube. As noted above, Weigand is silent with

respect to the entrance effect of the capillary tubes and that of the two sensing ports 22, 24. As such, Weigand does not disclose, teach, or suggest a corresponding method as recited in claim 14.

Accordingly, claims 1, 12 and 14 patentably distinguish over Weigand. Claims 2 and 6-9 depend directly or indirectly from claim 1 and patentably distinguish over Weigand for at least the above mentioned reasons. Accordingly, withdrawal of the rejections under 35 U.S.C. §102(b) over Weigand is respectfully requested.

Rejections Under 35 U.S.C. §103

Claims 3 and 11 were rejected under 35 U.S.C. §103(a) over Weigand. This rejection is respectfully traversed.

As a preliminary matter, each of claims 3 and 11 depend from claim 1 which patentably distinguishes over Weigand, as Weigand fails to teach or suggest a flow sensor wherein at least one capillary tube of a bypass has a length substantially equal to a length of a sensor conduit.

Moreover, although Weigand discloses various aspects of the capillary tubes of the bypass (e.g., square tubes having a hydraulic diameter of about 1.27mm), and discloses that the sensing ports 22, 24 each has a diameter of about 1.5mm, Weigand says nothing about the cross-sectional shape of the sensing ports. Accordingly, any assertion that Weigand discloses or teaches anything but square-shaped capillary bypass tubes is without any support in Weigand.

Furthermore, the only disclosure in Weigand about the sensing ports 22, 24 discloses that they do not have a cross-sectional shape that is substantially the same as that of the capillary tubes of the bypass. Indeed, the use of "hydraulic diameter" in Weigand to describe capillary tubes connotes a non circular cross-sectional shape, while the use of "diameter" to describe the sensing ports connotes a circular shape. Moreover, the sensing ports of Weigand have a diameter that is about 18% larger than the hydraulic diameter of the capillary tubes of the bypass. As noted above, substantially equal is used to define properties which are identical or nearly identical, but include variations which occur during production. A difference of 18% is not "substantially equal."

With respect to the Office Action's assertion that Applicant has not disclosed that having the capillary tube and the sensor conduit same shape solves any stated problem or is for any particular purpose, Applicant disagrees and directs the Examiner to the present application at page 7, lines 11-20, and page 9, lines 21-28. Embodiments of the present invention minimize the variation of the bypass splitting ratio by using capillary tubes of the same length and the same cross-sectional shape so that the same ratio L/(D x Re) is reached simultaneously in the sensor capillary tube and the bypass capillary tubes. Thus, the nonlinear characteristics of the sensor and that of the bypass match each other, to the extent that at a common pressure drop, substantially the same amount of gas will flow through the bypass capillary tube as will flow through the sensor capillary tube. The improved bypass linearity increases the accuracy of the senor reading over a wide range of flow rates and gas properties, the operable range of the flow sensor is increased at the high flow range of the sensor, and greater accuracy when switching between different fluids, thereby avoiding additional testing on other fluids.

Accordingly, claims 3 and 11 patentably distinguish over Weigand, and withdrawal of the rejection under 35 U.S.C. §103(a) is respectfully requested.

Claim 4 was rejected under 35 U.S.C. §103(a) over Weigand in view of U.S. Patent No. 5,804,717 to Lucas (hereinafter Lucas). This rejection is respectfully traversed.

Weigand is directed to a pressure-based flow meter having a pressure sensor that detects a pressure before and after a capillary section. Lucas is directed to a thermal-based flow meter and discloses multiple secondary flow paths comprising sensing tubes 22, resistance elements 22, and measuring circuit 18. (Lucas, column 6, lines 6-19.) Each of the secondary flow paths corresponds to a particular flow rate range for the fluid. (Lucas, column 7, lines 20-23.)

One skilled in the art would not have been motivated to combine Weigand and Lucas for any reason, let alone those asserted in the Office Action, because each utilizes fundamentally different approaches to measuring flow. Specifically, Weigand measures a pressure differential by comparing the pressure readings from each of the sensor ports. In contrast to Weigand, Lucas monitors a temperature gradient of a fluid passing through the sensor tube. One of ordinary skill in the art would not seek to combine the teaching of Weigand with those of Lucas, because

although each is directed to flow meter, each uses fundamentally different technologies to measure flow.

Furthermore, although the Office Action asserts it would have been "obvious" to have "used a capillary sized sensor as that taught by Lucas in the flow meter of Weigand for the purpose of having the ratio of fluid flow through the capillary tube and the bypass always be constant throughout the measurable range of laminar flow," even a cursory reading of the references refutes this assertion.

As an initial matter, the Office Action fails to note that all of the control electronics of Weigand would need to be scrapped and replaced with something else, as Weigand uses pressure to determine flow, and Lucas uses temperature. Secondly, the Office Action fails to address whether one, or both of the pressure sensors of Weigand should be replaced with the capillary sized sensor of Lucas. As both references include two sensor tubes, it would appear that the asserted combination would have one capillary sensor tube with its inlet and its outlet placed adjacent the bypass inlet of Weigand, and another sensor tube with its inlet and its outlet placed adjacent the bypass outlet of Weigand. However, claim 4 clearly distinguishes over this, as claim 4 (as dependent from claim 1) recites that the sensor conduit inlet is fluidly connected to the fluid inlet and the sensor conduit outlet is fluidly connected to the fluid outlet.

Thirdly, although the Office Action asserts that one of ordinary skill in the art would be motivated to combine the references so that the ratio of fluid flow through the capillary tube and the bypass would "always be constant throughout the entire measurable range of laminar flow," this is not what is taught by Lucas. Indeed, in the device of Lucas, the ratio of fluid flow through the capillary tube and that of the bypass is not constant throughout the entire measurable range of laminar flow; instead, it is divided into two or more distinct regimes, which, although constant in each regime, differ markedly from one regime to another by an order of magnitude. (See, Lucas col. 8, line 58 through column 9, line15). In brief, and for a variety of reasons, one of ordinary skill in the art would not combine the teaching of Weigand with those of Lucas for any reason, let alone the reasons asserted in the Office Action.

Moreover, even if the references were combined in the manner suggested by the Examiner, Lucas fails to cure the deficiencies of Weigand. Lucas fails to disclose, teach, or suggest a flow sensor comprising a bypass having at least one capillary tube and a sensor

conduit, wherein the at least one capillary tube has a length substantially equal to a length of the sensor conduit as recited in claim 4 as it depends from claim 1. As such, claim 4 is patentable over Weigand and Lucas, either alone or in combination. Withdrawal of the rejection of claim 4 is, therefore, respectfully requested.

Claims 10 and 13 was rejected under 35 U.S.C. §103(a) over Weigand in view of U.S. Patent No. 5,080,131 to Ono (hereinafter Ono). This rejection is respectfully traversed.

Weigand is directed to a pressure-based flow meter having a pressure sensor that detects a pressure before and after a capillary section. Ono is directed to thermal-based mass flow controller having a sensor tube with a thermal sensor and a bypass element 8.

One skilled in the art would not have been motivated to combine Weigand and Ono because each utilizes fundamentally different approaches to measuring flow for many of the same reasons as discussed above with respect to the combination of Weigand and Lucas. Weigand measures a pressure differential by comparing the pressure readings from each of the sensor ports. In contrast to Weigand, Ono monitors a temperature gradient of a fluid passing through the sensor tube.

Although there are numerous reasons why the asserted combination is refuted by the references, even if the references were combined in the manner suggested by the Examiner, the proposed combination would not have resulted in the invention as claimed. Ono discloses a bypass element 8 having bypass holes in the axial direction formed by providing concave groves 33 in the width direction on the surface of a strip body 11 and winding the strip body around a shaft 35. (Ono, column 8, lines 58-63.) There are no through holes in a portion other than the concave grooves and the flow rate is set by the number of concave grooves. (Ono, column 9, lines 1-5.)

The proposed combination of Weigand and Ono would not have resulted a plurality of apertures uniformly disposed about a periphery of the bypass as recited in dependent claims 10 and 13. The holes in Ono form the main flow channels of a bypass element positioned within the bypass, but are not uniformly disposed about a periphery of the bypass. As shown in Fig. 1 of Ono, the holes are disposed in the interior of the bypass. As Weigand is also silent as to a

plurality of apertures uniformly disposed about a periphery of the bypass, the proposed combination would have similar failings.

Moreover, Ono fails to cure other deficiencies of Weigand. As with the combination of Weigand and Lucas, Ono fails to disclose teach or suggest a flow sensor comprising a bypass having at least one capillary tube and a sensor conduit, wherein the at least one capillary tube and sensor conduit are substantially equal in length or have substantially the same entrance effect as recited in claims 10 and 13, respectively, as they depend from independent claims 1 and 12. Claims 10 and 13 are, therefore, patentably distinguishable over Weigand and Ono, either alone or in combination. Accordingly, withdrawal of the rejection of claims 10 and 13 over the asserted combination of Weigand and Ono is respectfully requested.

New claim 15 is directed, in part, to a flow sensor having a bypass fluidly connected to a fluid inlet and a fluid outlet of a housing, the bypass comprising at least one capillary tube, wherein the capillary tube is oriented substantially along a direction from the fluid inlet to the fluid outlet. Claim 15 depends from independent claim 1 and is patentable over Weigand alone or in combination with Lucas for at least the same reasons. Moreover, claim 15 is further distinguished from Ono, since the flow in Ono thorough bypass elements 8 is in a direction perpendicular to the direction from the fluid inlet to the fluid outlet.

CONCLUSION

In view of the foregoing amendments and remarks, this application should now be in condition for allowance. A notice to this effect is respectfully requested. If the Examiner believes, after this amendment, that the application is not in condition for allowance, the Examiner is requested to call the Applicant's attorney at the telephone number listed below.

If this response is not considered timely filed and if a request for an extension of time is otherwise absent, Applicant hereby requests any necessary extension of time. If there is a fee

occasioned by this response, including an extension fee, that is not covered by an enclosed check, please charge any deficiency to Deposit Account No. 50/2762.

Respectfully submitted,
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